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Workshop 3

College Education

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Abstract

Space Grant Colleges and Universities must build the space curriculum of the future on the firm basis of deep knowledge of an involvement with the present operating programs of the nation and an on-going and extensive program of leading edge research in the aerospace sciences and engineering, management, law, finance, and the other arts that are integral to our planetary society. The Space Grant College and Fellowship Program must create new academic fields of enquiry, a long and difficult process which will require deeper and broader interaction between NASA and academia than has previously existed.

Introduction

Our society has learned that increasing human knowledge extends the health, freedom, resources, and prosperity of our nation and the world. American society intends that college graduates acquire the skills to participate in increasing human understanding. In the later half of the 19th century the United States Congress realized that centers of higher education had to be created and nurtured in both the established and frontier states of America in order that Americans could develop the understanding of their land and its uses and to increase their abilities to envision and invent the future. To these ends a series of laws were passed that encouraged the system of national land grant colleges for the advancement of the agricultural and industrial arts (Morrill Act--1862; Hatch Act--1887; Merrill Act--1890). Congress provided 17.4 million acres of land and 8 million dollars of long term base funding in 1861. In 1887 each state was granted \$15,000/year. In 1890 an additional \$15,000/year was provided and an annual increase of \$1,000/year for 10 years was used to accelerate the growth and vitality of these land grant institutions. This vigorous support was rewarded. In 1860 the nation had 4 schools of engineering. By 1885 there were 85. The Smith-Lever Act and over 30 other educational measures passed in the first two decades of the Twentieth Century greatly extended the federal support of higher education. Now land grant colleges and universities award over 468,000 degrees annually, including over 33.5% of all bachelor's, 33% of all masters, and 60% of all doctoral degrees (NASULGC 1989). These federally aided institutions now play a major role in the advancement of the aerospace activities of the nation.

America, along with most of the advanced nations of the world, makes significant and growing expenditures in aerospace activities. In 1990 the United States will expend over 150 billion dollars in aerospace (AW7ST 1990). The expenditures are approximately evenly divided between the three categories of space and missiles, military aircraft, and commercial transport and business flying. Total world expenditures in these fields are approximately three times greater. In the era of declining world tensions expenditures on military aircraft and missiles are declining. However, expenditures on commercial air transport and business flying and space programs are growing. Aircraft link the people of the world to such an extent that at any one time approximately 1 person in 10,000, of the entire population of the world, is in an aircraft above 10 kilometers altitude and traveling within 80% of Mach 1. An educated person of the 1880s would view this vast number of people as almost being space travelers. In 1887 the academician Ernst Mach published the first photograph of a supersonic shock wave (Anderson, 1985). In less than 100 years the world has moved from the academic demonstration of supersonic flow about a rifle bullet to more than 400,000 people flying near Mach 1 day in and day out over all the lands and seas of Earth. Aviation has fundamentally changed the world. People, parcels, threats, and mail now travel far easier internationally than they did locally one hundred years ago.

An immense range of skills are necessary to support the present day hero activities of the nation. They clearly include technical subjects such as materials science, aeronautics, propulsion, electronics, computer science, physics, mathematics, flight medicine, and meteorology to name only a few. The required skills extend to the creation and maintenance of the large government and private organizations (Federal Aviation Administration, airline companies, manufactures, international and support organizations), civil engineering firms, and fuel companies. business administration, international relations, finance, accounting, economics, government relations, advertising, marketing, insurance, and food preparation are but a few of the professional skills that have enabled the large and dynamic aero-industry. People with these human and organizationally directed skills envelop and direct the technical accomplishments of aircraft and airports and create the overall organizations that tie diverse parts of American and the world together via the living systems of aircraft and airlines.

Many of the core technological and organizational skills grow directly from the educational activities of Land Grant Universities. The Land Grant Universities teach their students how to build and grow using the tangible resources of Earth. Stepping beyond Earth provides new challenges to America, its people, and its system of higher education. In the Nineteenth Century the challenge was to build a new civilization across the face of America using the resources under foot. The next step is far more difficult. Many of the major resources are remote and the basic machines remain to be derived from our terrestrial experience or invented. Our expectations have to be extended in scope. Our motivations must be extended beyond the rewards of exploration and the familiar but limited examples provided by local (Earth centered) communications, remote sensing, and defense. Large teams will be necessary to cultivate the seeds of economic growth beyond Earth. Many individuals must struggle and search for years at the frontiers of knowledge to discover and direct our national teams to higher accomplishments.

America has been committed since the 1950s to the exploration and exploitation of space. World investments have grown far beyond the tiny research expenditures by the Smithsonian Institute, \$5,000 in 1917 to an obscure Robert H. Goddard (Anderson 1985). Now world expenditures exceed 60 billion dollars annually. Much of the original investment was for the development of nuclear ballistic missiles and the Apollo program. The world space program has widened in scope. Space satellites monitor the world for natural and human threats, look outward into the universe, and link people worldwide through radio and television. Immense stores of data have been collected concerning the moon, the planets, objects in deep space, the sun, and the Earth. Future programs such as Hubble Space Telescope, the other great observatories, and the Earth Observing System (EOS) will require large numbers of new scientists and engineers to study the observations and change them into knowledge and practical applications. Already over 300 people have ventured to orbit about earth and 12 people have been to the moon and returned with samples, geophysical data, operational knowledge, and the understanding that humans can work and live beyond Earth if they are supported by extensive ground operations. In the 1990s people will permanently reside in orbit about Earth.

On July 20, 1989, President Bush committed the nation to the emplacement of a permanent base on the moon and the planning of an expedition to Mars.

"The time has come to look beyond brief encounters. We must commit ourselves anew to a sustained program of named exploration of the solar system--and yes--the permanent settlement of space. We must commit ourselves to a future where Americans and citizens of all nations will live and work in space...And our goal is nothing less that to establish the United States as the preeminent space faring nation".

NASA (1989) responded to that Human Exploration Initiative (HEI) challenge with a Presidentially requested report that synthesizes the many studies of moon and Mars exploration missions that have been provided since the pre-Apollo era and were under intense study during the last three years. A special committee of the National Research Council (1990) reviewed the NASA (1989) report. They noted that a decades long commitment would be required for the success of HEI. The committee's final comment was--

"Last, the committee believes that, whatever the selected architecture for *HEI, there is a need for a new emphasis on advanced technology development and that it is highly desirable to continue to cast a wide net for innovative concepts".

If America is to continue to reap benefits from its investments in space activities we must invent the means by which Americans will travel to and live in space and use the resources of space to propagate beyond Earth. There is no fundamental reason that travel from Earth to orbit cannot be as common and inexpensive as trans-oceanic flight. The challenges are greater than those that faced the our great grandparents as they migrated westward across America in the 1800s; however, our modern society possesses far greater resources, knowledge, wealth, and tools. To this end the 100th Congress received and the 101st Congress of the United States passed the National Space Grant College and Fellowship Act and instructed NASA to establish and manage the program (Congressional Record 1987, 1989). The primary challenge of the National Space Grant College and Fellowship Program is to establish the college and university systems that will produce graduates trained to invent the useful, independent future of Americans beyond Earth and manage the development of space activities for the benefit of Earth.

National Purposes

Congress intends that the Space Grant activities take a broad view of the fields to be considered. In the Congressional Record (1987, p. S 3207, Sec 4. (4)) the following definition is given:

* "HEI", later was modified to SEI, the Space Exploration Institute.

"(4) the term "field related to space" means any academic discipline or field of study (including the physical, natural, and biological sciences, and engineering, space technology, education, economics, sociology, communications, planning, law, international affairs, and public administration) which is concerned with or likely to improve the understanding, assessment, development, and utilization of space";

The purposes of the Act (per Section 3) are to:

"(1) increase the understanding, assessment, development, and utilization of space resources by promoting a strong educational base, responsive research and training activities, and broad and prompt dissemination of knowledge and techniques;

(2) utilize the capabilities and talents of the universities of the Nation to support and contribute to the exploration and development of the resources and opportunities afforded by the space environment;

(3) encourage and support the existence of interdisciplinary and multidisciplinary programs of space research within the university community of the Nation, to engage in integrated activities of training, research and public service, to program of the National Aeronautics and Space Administration;

(4) encourage and support the existence of consortia, made up of university and industry members, to advance the exploration and development of space resources in cases in which national objective can be better fulfilled than through the programs of single universities;

(5) encourage and support Federal funding for graduate fellowships in fields related to space; and

(6) support activities in colleges and universities generally for the purpose of creating and operating a network of Institutional programs that will enhance achievements resulting from efforts under this Act".

Educational Goals

The Educational Panel focused on higher education. Other panels considered K-12 education, outreach, and other relevant functions. Thus the focus of this panel report is college level undergraduate and graduate education and research and post-doctoral research. The primary goals for higher education were determined to be:

- * Provide graduates with advanced skills in aerospace disciplines that support United States space activities through formal courses and research programs
- * Participate in recognizing and defining the needed programs of higher education for support of the national activities in aerospace
- * Support programs of post-college professional education
- * Provide educational and research experiences off Earth
 - Via telemetry
 - Eventually in situ
- * Help in defining the long-range planning guidelines and priorities for future space activities
- * Establish requirements of K-12 and external programs
- * Make space education a permanent part of state education

The Land Grant Colleges helped to elevate the agricultural and industrial skills of the nation to economic world prominence in less than fifty years. The system of the National Space Grant Colleges should strive to surpass that performance. The intellectual challenges are immense but the rewards are greater. Eventually the graduates of National Space Grant Colleges will provide homes in space that will support humans and a wide range of other life independent of Earth, will dependably tap the immense engeries of the sun, convert resources of the solar system to human use, and greatly extend our knowledge of the universe. A vast range of new options will be created for our children's children. However, deep understanding of our present capabilities and clear, precise projections of our knowledge will be required to profitably expand beyond Earth.

Issues

Space Grant Colleges and Universities must build the space curriculum of the future on the firm basis of deep knowledge of and involvement with the present operating space programs of the nation and an on-going and extensive program of leading edge research in the aerospace sciences and engineering, management, law, finance, and the other arts that are integral to our planetary society. All aspects of NASA (operations, space sciences, management and financial, legal), portions of the DoD space programs, and other government space programs must be accessible to study, participation, and evolution by this new academic community the U.S. Congress has offered to the nation.

The government space programs of the 20th century are the "barrier islands" that must be used to access and create the "new lands" in space in the 21st century. In the 21st century this movement must be both physical and intellectual.

There must be significant government, state, and private funding for the development and conduct of programs of higher education. Now, and for the foreseeable future, most graduates will find employment in government laboratories and in companies that are supported through government contacts. Every effort should be made to recognize these employment needs and plan educational programs that will provide the needed professionals. It must be realized that establishment of new courses, degree programs, departments, and even "space" campuses will be decades long activities that absolutely require steady support at the national level both by Congress and the agency assigned to age the National Space Grant and Fellowship Program.

Graduate research usually requires projects that are of one to three years duration. Space projects often involve decade or longer programs. The full range of national aerospace activities must be examined to find and create research opportunities that support undergraduate and graduate research.

New space markets must be invented and developed over a period of decades that will broaden the economic base of space industries. Many, if not most, of the new ideas that will grow to economic importance will well up from the fertile minds of students in Space Grant Colleges and Universities. Steady support and encouragement must be given to cultivate new advanced concepts for scientific and economic activities. Space program activities are traditionally computer intensive and the use of computers use continues to grow. The Polaris and Apollo programs introduced the nation to the extensive use of computers to plan and execute major high technology projects. Special efforts will be needed to expedite the use of computers as personal tools for education, research, and future employment.

Graduates of Space Grant programs should be recognized and encouraged to make use of their special training and research. Courses, interdisciplinary and distinct degrees, and professional designations should be defined. NASA, other government agencies, and private organizations should strive to make use of their particular talents and training. Professional societies should be formed that cultivate and encourage the interdisciplinary activities of space grant graduates.

Existing state programs of education and economic development should be used and extended to encourage the growth of space related activities nationwide. Professors in and graduates of Space Grant programs can provide the guidance for the definition and development of K-12 and extension services within each state.

Actions

There are specific actions that should be taken to build on the major strengths of our existing systems of higher education. A comprehensive assessment should be made of existing educational programs in aerospace science and engineering and related fields. The results should be made readily available and annually updated. The assessment should include listings of academic professionals, their interests, academic institutions involved in aerospace related work, curricula, lists of source materials and aids in accessing them, definitive listings of government resources expended on aerospace related education, and a listing of government organizations active in planning, assessing, and directing educational expenditures. Interdisciplinary activities should be emphasized. This review and assessment should be done by a joint university/government panel and participation by industry should be encouraged.

A series of curricula workshops should be conducted at which the needs for and content of future programs of higher education in the aerospace sciences and engineering and related fields are debated and recommendations are made as to content and emphasis. The participants of these workshops should have access to the above information and studies in a timely manner.

A major NASA and DoD effort should be started to understand the possibilities and payoffs that could be afforded by the economic expansion of mankind beyond Earth, by access to resources of the solar system, and the capabilities that might be possible for a society that operates freely far beyond our planet. There will be a few easy insights and extrapolations. However, most of the work will be as long range and difficult as that required in the development of new agricultural crops and demonstrating the utility of extension services in the early 20th century. A permanent and significant commitment to long range planning must be established at the academic level that has not been afforded to any nation, even during Apollo. Extensive use should be made of the data and experience obtained during the Apollo program as a focus for advanced groups to consider how humans can begin to live off the Earth using non-terrestrial resources.

A new academic community must be formed, somewhat in the manner that was done for lunar sample and lunar science investigations during the Apollo era. The community will be different. It will encompass a wider range of disciplines, interests, styles of research, and types of reward. There will be more connections to industrial concerns and more international interactions. This new academic aerospace community must be provided with a richer set of opportunities for aerospace related research by both professors and students. The students must have options for 1 to 3 year projects.

The Land Grant Colleges bring new technologies and new techniques to the practices of agriculture and industry. The same must be true for the National Space Grant Colleges and the aerospace industry. These new contributions can be expedited by changes to government policies for procurement and competition of aerospace programs. Industry should be encouraged and enabled to participate far more deeply in the development of higher education and long range research programs in aerospace sciences and engineering.

NASA should fund research and development of computer hardware and software supportive of aerospace education. NASA will benefit by developing better techniques for people to understand and control complex systems.

Long Term Development

We note that the United States has made a permanent and significant commitment to the development of American interests beyond the Earth. These commitments started with the National Space Act in 1957 and have expanded through national and international law, growing civilian and domestic space programs, and an increasing web of international agreements and programs. These commitments have been enabled primarily by the engineering knowledge in rocketry, aeronautics, materials, and systems formulated before that 1970s. The newly formed Space Engineering Research Centers constitute one aspect of the needed NASA support of the National Space Grant Colleges and Fellowship Consortia.

However, what has not happened is an increasing commitment to understanding how to systematically use the burgeoning technologies and sciences, of an opening world society to meet its environmental and economic needs during the later part of the twentieth century. The drive to develop space resources to meet the needs of humans on Earth can greatly accelerate our development of resources off Earth and expedite the permanent presence of rapidly growing numbers of Americans beyond Earth. The organizations established under the National Space Grant College and Fellowship Act can provide the environment and rewards conducive to long range research and the context within which the young can be trained to invent and lead our society into the national future in space.

The National Space Grant College and Fellowship Program must create new academic fields of enquiry. This is a long and difficult process. It cannot be mandated or contracted into existence. Much deeper and broader interactions will be required between NASA and the fledgling communities than have occurred in the past. There are many lessons to be learned from the success of NASA in establishing vigorous communities in the space sciences. It will be necessary to balance the needs for immediate evidence of progress against support of longer term research teams. Above all the program must be open and allow vigorous debate and examination of all issues--just as happens in the healthy academic community. Such debate will create pain, that, like most birth pains, will push these new academic creatures into a wider world.

References

- Anderson, John D. (1985) Introduction to Flight, 560pp., McGraw-Hill Book Co.
- Aviation Week and Space Technology (March 19, 1990) Aerospace Forecast and Inventory, p. 38-39 and p. 177-192.
- Congressional Record (February 8, 1989) SENATE - Excellence in Mathematics, Science, and Engineering Education Act, p. S 1129-S 1144.
- Congressional Record (March 17, 1987) SENATE - Space Grant College and Fellowship Act, Vol. 133, #42, p. S 3206-S 3209 and HOUSE Section 201 p. H 8315-H 8316 and H 8320-H 8322.

National Association of State Universities and Land-Grant
Colleges (1989) Fact Book, 44pp., One Dupont Circle N.W.,
Washington, D.C.

NASA (1989) Report of the 90-Day Study on Human Exploration
of the Moon and Mars, 150pp., 9 sections Code RZ,
Washington, D.C 20546

National Research Council (1990) Human Exploration of Space -
A Review of NASA's 90-Day Study and Alternatives, 63pp.,
National Academy Press, Washington, D.C.

College Education Panel
(National Space Grant College and Fellowship Program)

Goals

- * Provide the Nation with college and university graduates who are trained to understand, invent, and help direct the beneficial future presence of the United States off Earth.
- * Do this by establishing the major new National Space Grant College (NSGC) programs that provide the educational and research opportunities.
- * Provide educational experiences off Earth
 - Via telemetry
 - Eventually in space
- * Make space education a permanent part of state education
 - Establish requirements of K-12
 - Establish teacher training and External education program
- * Link NSGC programs to industry, government, and NPO space activities.

Issues

- * Defining, establishing, and evolving new curricula and research unique to NSCGs
 - Present unfulfilled needs of government, industry, and NPOs
 - Processes to identify and meet future needs
 - Coping with long time scales to identify and establish courses, course materials, tests, degree programs, departments, schools, professional societies
 - providing space related research programs of 1 to 3 years span (MS and PhD)
- * Learning how to invent and establish new beneficial activities beyond Earth
- * Funding long term educational programs that support
 - Government dominated markets now
 - Commercially dominated markets later
- * Using existing state programs efficiently
- * Recognizing the graduate
 - Courses, interdisciplinary or distinct degrees
 - Professional designations (ex. Space Lawyer, Prof. of Space Engineering)

- * Using computers and networks in education
- * Meeting AA & outreach goals (topic of other working groups)

Actions

Form Working Groups

- To define the curricula needed by governments, academics, industries and NPOs
- To define the unique research needs of undergraduate, MS, and PhD students and post doctoral fellows.

Conduct Resources Analyses

- Identify present aerospace courses, texts, degree programs, teachers
- Identify existing demonstration and research facilities at universities, national laboratories, and industry

Others

- Annual conference and publication on higher education and university research
- Link NSGC to general education (Astronomy-20% of science education courses)
- Project new markets (10-15 years; ex. New Earth-space links, lunar manufacturing)
- Link NSGC curricula and research programs to operational NASA and DoD programs and encourage industrial funding of academic research